DTE Energy
Detroit Edison

LIGHTING

State Energy Assessment Workshop

By:

DTE Energy Partnership & Services

Objectives

This presentation will cover:

- Lamps Characteristics
- Lamps types/Ballasts/Fixtures
- Determination of lighting needs
- Maintaining the lighting system/ re-lamping Strategies
- Calculation of energy saving of lighting projects
- Green Light Program, And Lighting Control strategies

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Lamps Characteristics

Lighting Terminology

- **Lumens**

  is a measure of the gross light output from the lamp. A higher lumen is a brighter lamp.

CRI

Lamp Color or (Color Rendering Index) is the rating given to a lamp as to how well it represents the true colors of the objects it illuminates. A higher CRI (80 - 90) means the light source is very true to color. A low CRI (under 50) means the light does not correctly indicate most colors.

Lighting Terminology

- **Efficacy**

  is similar to efficiency, but since the units are different, they had to come up with a different name. Efficacy is Lumens Output / Watts Input, or Lumens per Watt. Efficacy is way to compare different kinds of lamps to a common measurement. A higher Efficacy means a more efficient light, as it relates to energy usage, but not necessarily a better light for a given task.

Lighting Terminology

- **Foot Candle Standard**

  is the measure of light required for adequately lighting a space. Most codes and standards will specify a given 'Foot Candle' for a particular space or task. Foot Candles are the same as Lumens per square foot.

- **Lux**

  is a metric measurement of light on a surface; 1 Lux = 1 Lumen per square Meter. Since there are about 10 square feet in a square meter, 1 Lux is about equal to 10 Lumens.

Lighting Terminology

- **LPD**

  is Lighting Power Density, a measure of electrical power used to light a given space. Units are watts per square foot, so a high LPD means more watts per square foot. Energy Codes use the LPD to determine the lighting system energy efficiency.

- **CU**

  is Coefficient of Utilization, which is a ratio of lumens from a fixture received on the workplace compared to the lumens emitted by the lamps. A high CU means a quality fixture correctly installed such that most of the available light from the lamp reaches the places it needs to be.

Artificial Light Sources

- Incandescent *(INC)*
- Fluorescent *(FL)*
- Mercury Vapor *(MV)*
- High Pressure Sodium *(HPS)*
- Light Emitting Diode *(LED)*
- Tungsten Halogen *(TH)*
- Compact Fluorescent *(CPL)*
- Metal Halide *(MH)*
- Low Pressure Sodium *(LPS)*

Incandescent Lamps Advantages

- Inexpensive
- Available in Different Configurations & Colors
- No warm up is required
- Easily controlled

Incandescent Lamps Disadvantages

- Inefficient (10- 25 lumens/watt)
- Short lamp life
- Vibration sensitive
- Over-voltage sensitive

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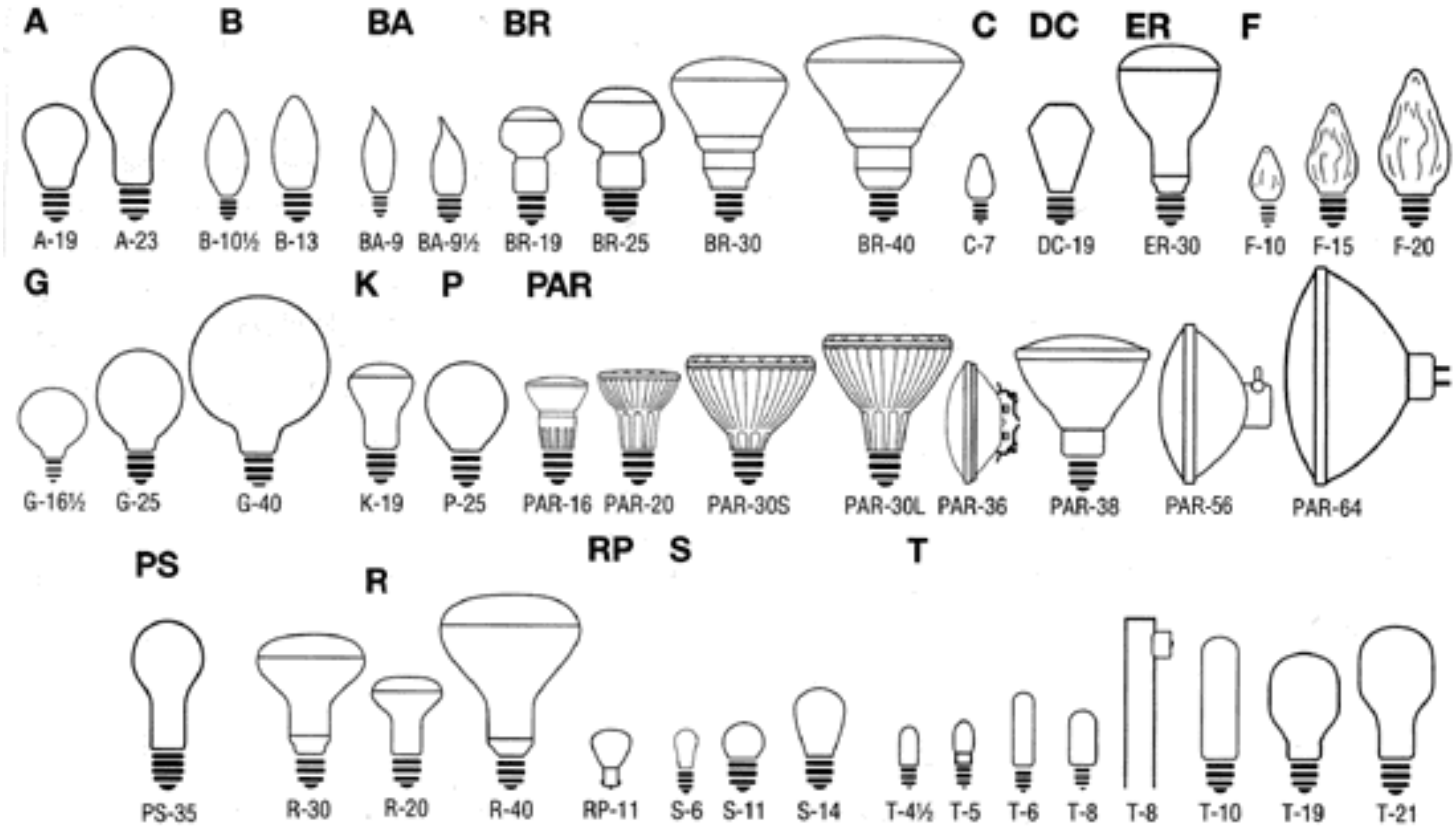
Incandescent Types



Fluorescent Lamps

- Lamps are available in the following configurations
- T5
- T8
- T10
- T12
- T17

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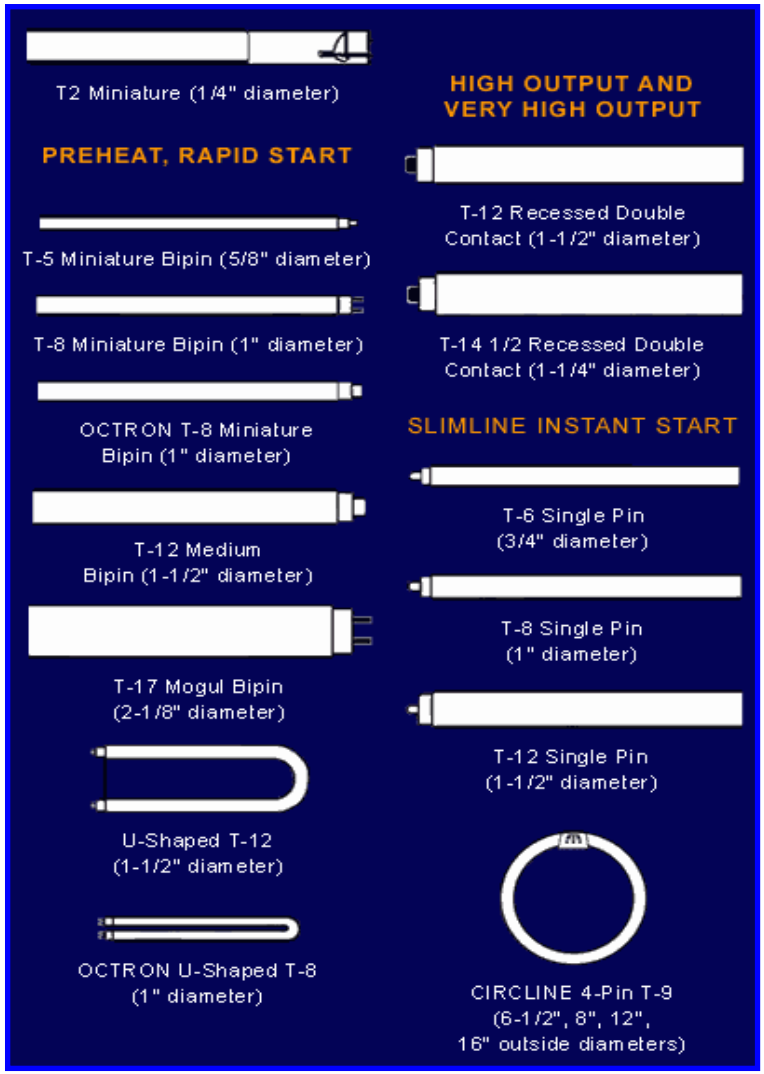
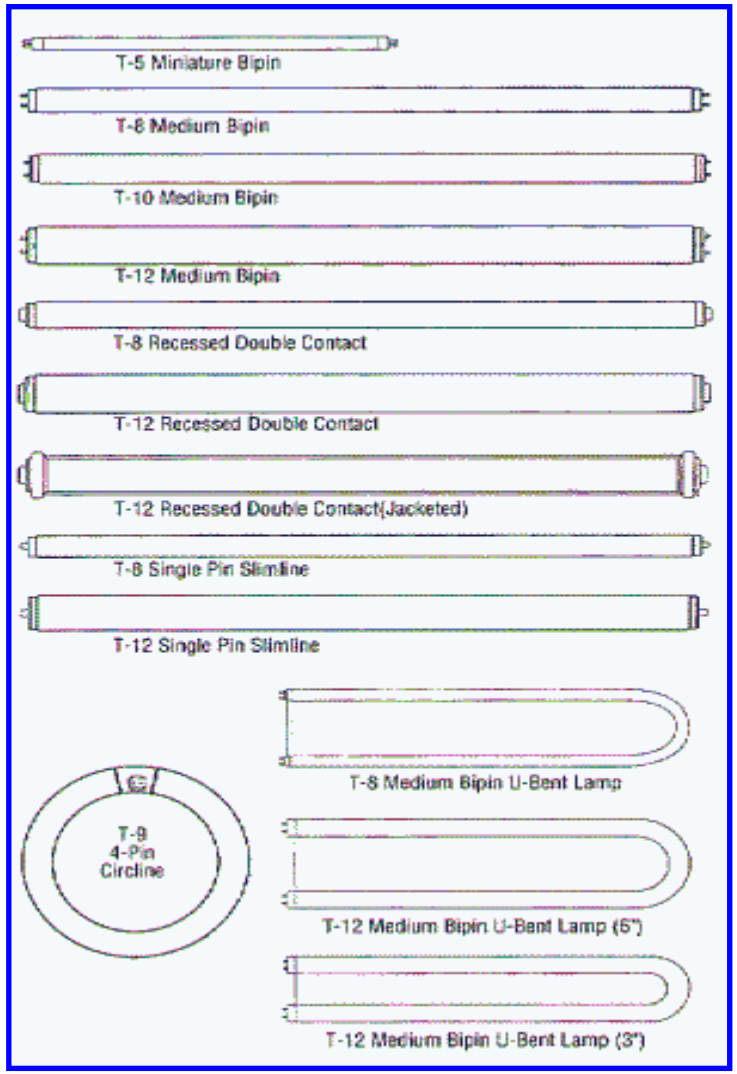
Fluorescent Lamps





Fluorescent Lamps T8 Lamps

- Tubular lamp 8/8 of an inch, or 1:0, in diameter, and is typically used with electronic ballast
- Standard lamp wattages: 32W and 55W
- Ho (High Output) versions are also available

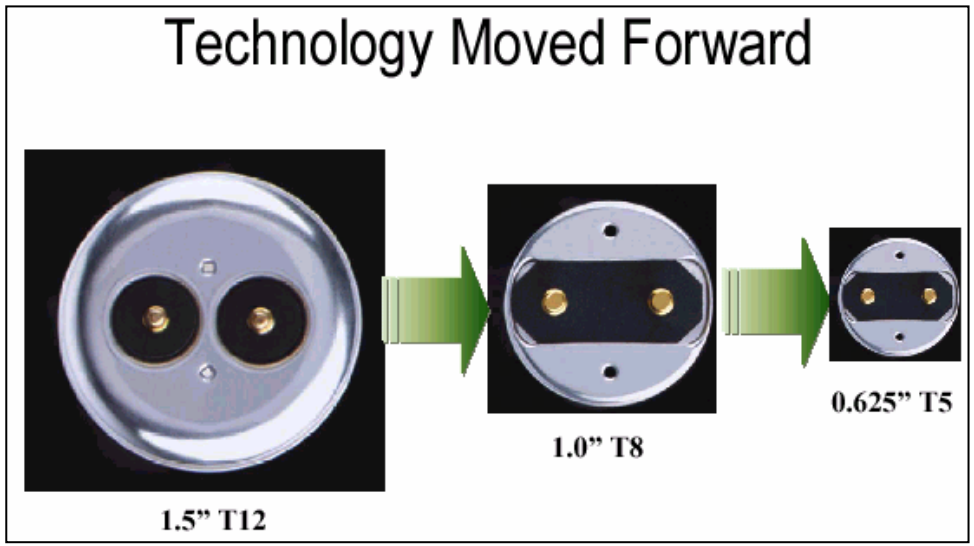
Fluorescent Lamps T-5 Lamps

- Tubular lamp 5/8 of an inch on diameter
- Typically is used with electronic ballast
- Standard lamp wattages: 14W, 21W, 24W, and 35W

Fluorescent Lamps T-12

- Such as, GE Lamps- Watt-Miser (WM)
- Phillips lamps – ECONO-Watt (EW)
- Osram/ Sylvania Lamps– Super Saver (SS)

Fluorescent Lamps



Fluorescent Ballasts

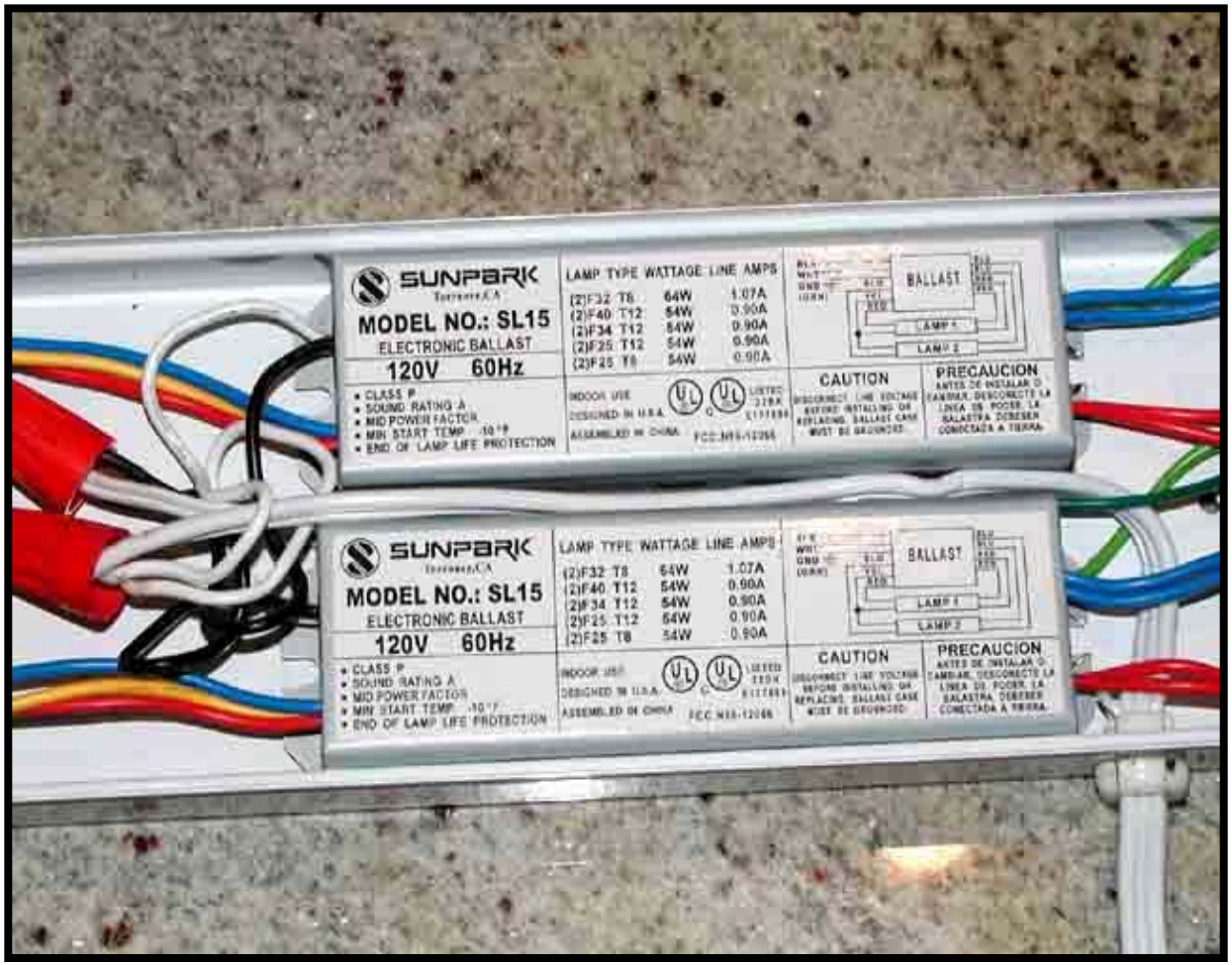
- Ballasts perform two basic functions

1. Provide the higher voltage required to start lamps
2. Stabilize the lamp current

Fluorescent Ballasts Comparison

- Input Wattage Comparison of Four-Lamp 40 watt each, Fluorescent Fixtures
- Electromagnetic 188 W, Electronic 128 W

Ballasts


SUNPARK
MODEL NO.: SL15
ELECTRONIC BALLAST
120V 60Hz
• CLASS P
• SOUND RATING A
• MID POWER FACTOR
• MIN START TEMP -10°F
• END OF LAMP LIFE PROTECTION
LAMP TYPE WATTAGE LINE AMPS
(2)F32 T8 64W 1.07A
(2)F40 T12 54W 0.90A
(2)F34 T12 54W 0.90A
(2)F25 T12 54W 0.90A
(2)F25 T8 54W 0.90A
BALLAST
LAMP 1
LAMP 2
CAUTION
PRECAUCION
SUNPARK
MODEL NO.: SL15
ELECTRONIC BALLAST
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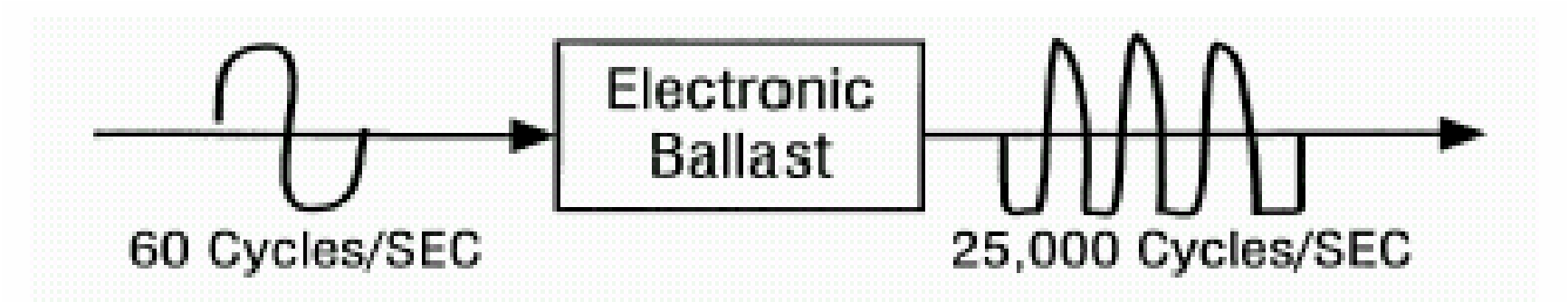
Fluorescent Electronic Ballasts



Electronic Ballasts Characteristics

- Up to 40% efficiency improvement over electromagnetic ballasts
- No ballast “hum”
- Cooler operation for reduced air conditioning load
- Can drive up to 4 lamps/ballasts
- Low temperature operation
- Causes Harmonics

Electronic Ballasts Characteristics Continue..

- High power factor
- Low THD
- Light weight
- Instant on
- No flicker
- Universal input voltage

Fluorescent Lamps Advantages

- Efficient(75+ lumens/watt)
- Available in many configurations
- Desirable colors available (2,700K to 4,100K)
- Long life (6,000 – 20,000 hours)

Fluorescent Lamps Disadvantages

- Require a ballast
- Temperature sensitive
- May require special controls

High Intensity Discharge (HID) Lamps

- Mercury Vapor
- High Pressure Sodium
- Metal Halide

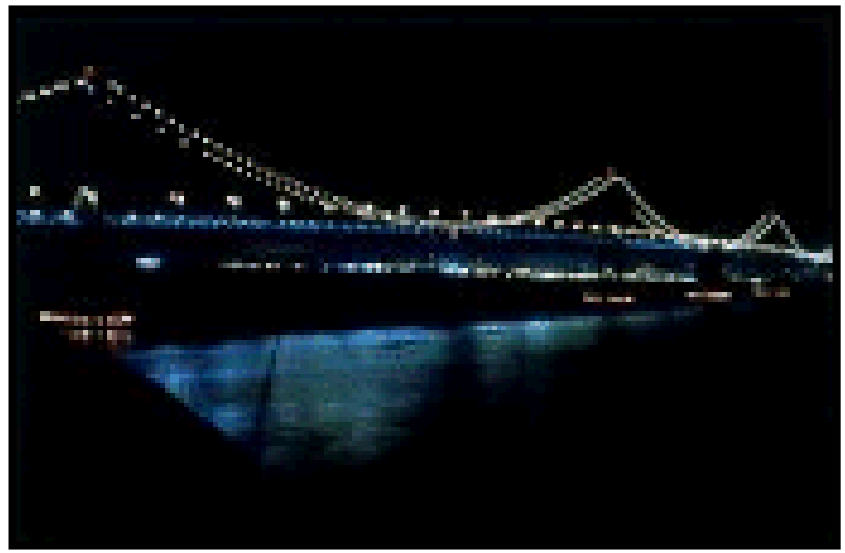
HID Lamps Characteristics

- All HID lamps share certain physical and operating characteristics:

1. All HID lamps utilize an internal arc tube and outer envelope construction
2. All HID lamps require a ballast for operation.
3. All HID lamps require warm up period
4. All HID lamps require cool-down period before they can re-strike

Mercury Vapor Lamps

- Mercury vapor lamps produce a bluish-green color light. Due to their lower efficacy and poor color rendition they are seldom used in new construction. Most current usage is for outdoor areas/ parking lot lighting. Mercury vapor lamps can provide certain low cost options for replacing less efficient lamps such as incandescent lamps without changing the fixtures.



Metal Halide Lamps

- Metal halide lamps are similar in construction to MV lamps. Some MH lamps can be operated off a MV ballasts.
- MH lamps offer a number of advantaged over MV lamps. They include
- Higher efficacy (~ 100 lumens/watt)
- A crisp clear white color
- Excellent color rendering (CRI 70 – 85)
- MH lamps is the choice where color rendering is critical, such as car lots, service stations, athletic fields, industrial manufacturing

Pulse Start MH Lamps

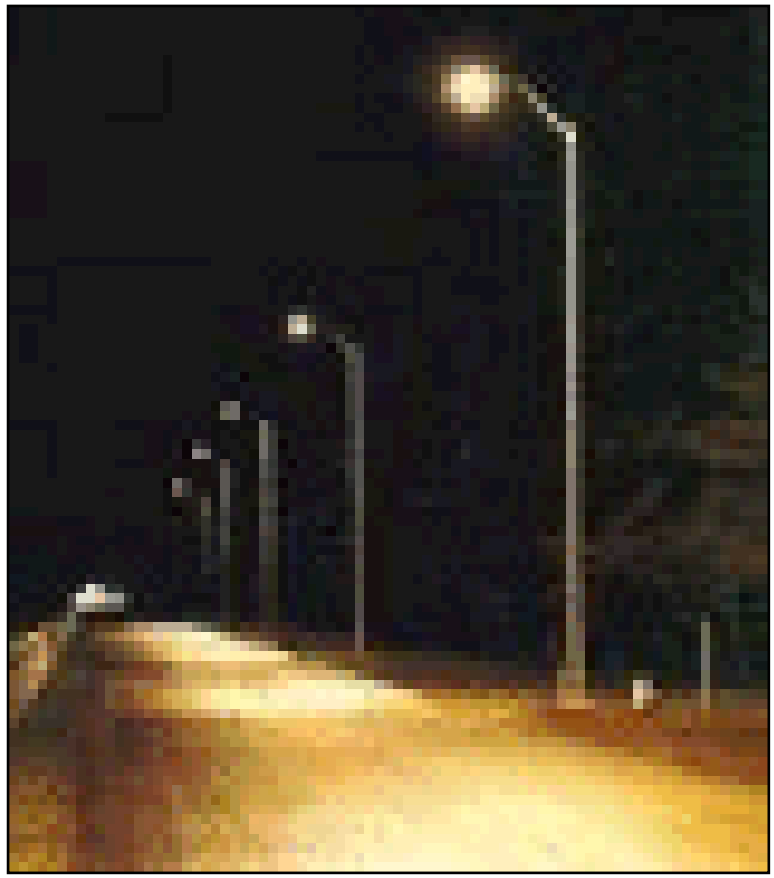
- Pulse start MH lamps utilize an improved ballast design to improve operation
- Higher efficacy
- Faster warm-up and re-strike longer life
- Better color uniformity
- Energy & maintenance savings(15%)
- Lamps are offered in a variety of sizes ranging from 50 watts(3,200 initial lumens) to (50,000 initial lumens). Lamp sizes: 50,70,100,150,175,200,250,350, 400, and 450W

Metal Halide Lamps Disadvantages

- Color shift toward the end of lamp life
- Some lamps are designed for enclosed fixtures only
- Orientation sensitive (horizontal vs. vertical)

HPS Lamps

- High pressure sodium lamps are used for both interior and exterior applications, efficacy (~120 /watt/lumens), mainly used for street lighting. It provide a golden- yellowish color light. Advances in electronics now make it possible to dim HPS fixtures in a cost effective manor such as production areas and warehouses.



LPS Lamps

- LOW Pressure Sodium is not an HID source. IT is a gaseous discharge type lamp, similar in operations to fluorescent lamps.
- While very efficient (160 lumens/watt), LPS lamps are monochromatic light source. They produce only one light color, a dirty yellow color. That is CRI for LPS is negative.

Exit Signs Types

- Incandescent
- Fluorescent
- LED
- Tritium

Things We Need To Know

About 20% of all electricity generated in the united states today is used for lighting.

Lighting Needs

- Determine the Right Lighting Levels for different tasks.
- Not all lighting needs are the same. And the light provided to the employees to do their job impacts their productivity, safety and health.

How Much Light Is Enough?

- The most successful lighting plans use a variety of lighting sources including low-level ambient lighting and ultra-bright task lighting.

Chart to Understand Lighting Needs

Need/Task	Location	Footcandles	Lighting Effects
Safety & security in an unoccupied outdoor area	Public spaces with dark surroundings	3	Overall ambient lighting
Visibility for short visits or walk-throughs	Corridors, inactive storage areas, dining areas in restaurants	7.5	Overall ambient lighting
Service-oriented work with minimal visual tasks	Office and hotel lobbies, elevators, stairways, washrooms, active storage.	15	Overall ambient lighting

Chart to Understand Lighting Needs

Need/Task	Location	Footcandles	Lighting Effects
Shop or office work that involves high-contrast or large-size visual tasks.	Conference rooms, general office and shop areas, cashiers.	30	Task lighting
Shop or office work that involves medium-contrast or small-size visual tasks.	Office desk areas, machine shop task lighting, restaurant kitchens.	75	Task lighting.
Drafting, general health care examinations, proofreading, and other tasks of low contrast or tiny size.	Operating rooms and health care facilities, drafting rooms, some offices.	150	Task lighting.

Chart to Understand Lighting Needs

Need/Task	Location	Footcandles	Lighting Effects
Cutting and sewing textiles, jewelry or watch repair, and performing other tasks of low contrast or tiny size for prolonged periods.	Garment-manufacturing facilities, jewelry-manufacturing facilities, repair facilities.	300	Combination of ambient and task lighting.
Precision arc welding, surgery, metal finishing, and other prolonged and exacting visual tasks.	Hospitals, metal-manufacturing facilities, finishing facilities.	750	Combination of ambient and task lighting.
Product inspection, and other tasks of extremely low contrast and small size.	Textiles facilities, jewelry facilities, metals facilities.	1500	Combination of ambient and task lighting.

Maximizing Lighting Maintenance

- Regular maintenance is essential to ensure that facilities receive the desired quantity and quality of light, as well as energy efficiency, from their lighting systems.
- Periodic maintenance can produce a range of benefits, including a brighter and cleaner workplace, a higher level of security, and enhanced productivity.

Within maintenance system, maintenance and engineering managers have a number of strategies that can increase efficiency and savings when it comes to lighting system operation.

Re-lamping

- Schedule re-lamping at 70 percent of rated lamp life, the point on the lamp mortality curve at which 10 percent of burnouts have occurred.
- Purchase 10 percent more lamps than required for the group re-lamping.
- Use the 10 percent overstock only to replace burnouts that occur in that group after the group re-lamping.
- Re-lamp that group again when the 10 percent stock is depleted.

Lighting Maintenance Self-Check

To determine a lighting system's level of effectiveness, maintenance and engineering managers can use this lighting maintenance self-check:

- Locate an area of 100 fixtures, preferably with the same number of lamps per fixture
- Count the number of missing, burned out
- Divide this number by the number of lamps per fixture.
- Count the number of fixtures with broken, discolored lenses or missing parts.
- Count the number of dirty fixtures.
- Add the values from steps 3, 4, and 5.
- Grade: 0-10, keep up the good work; 11-20, need to spend more time; more than 20, spend much more time or consider outsourcing

How To Calculate Savings - *cont'd*

Energy Savings =

(Watts Saved ÷ 1000 Watts/kW) X ($-Cost per kWh) X (Operating hours)

For calculating annual energy savings:

Operating hours = Hours on per day X Days per week X 52 Weeks

Case Study:
T12 *vs.* T8

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Typical wattage values:
- 4 lamp fixtures
- 48" fluorescent lamps

Compare 40 Watt T12 w/mag. ballast with 28 Watt T8 w/elec. ballast

Lamp & Ballast	Energy Usage (Watts)
40 Watt T12 - Mag	**188**
40 Watt T12 - EEMag	172
40 Watt T12 - Elec	144
34 Watt T12 - Elec	120
32 Watt T8 - Elec	112
28 Watt T8 - Elec	**101**



T12 *vs.* T8

Lighting Efficiency |

40 Watt T12 vs. 28 Watt T8

188 Watts * 100 Fixtures
= 18,800 Watts

101 Watts * 100 Fixtures
= 10,100 Watts

Save $2,714.40 per year with T8

Additional savings:

- High efficiency ballasts
- Programmed rapid start ballasts
- More efficient fixtures
- Reduce number of lamps

Lamp and Ballast	Watts per Fixture	Number of Fixtures	Watts per Room	Yearly Burn Hours	kWh per Room	Cost per kWh	Cost per Year
40 W T12 - Elec	188	100	18,800	3120	58656	$0.10	$5,865.60
28 W T8 - Elec	101	100	10,100	3120	31512	$0.10	$3,151.20

Case Study: Incandescent *vs.* CFL

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INCANDESCENT vs. COMPACT FLUORESCENT BULBS		
Bulb Type	**100W Incandescent**	**23W Compact Fluorescent**
Purchase Price	**$0.75**	**$11.00**
Life of the Bulb	**750 hours**	**10,000 hours**
Number of Hours Burned per Day	**4 hours**	**4 hours**
Number of Bulbs Needed	**About 6 over 3 years**	**1 over 6.8 years**
Total Cost of Bulbs	**$4.50**	**$11.00**
Lumens Produced	**1,690**	**1,500**
Total Cost of Electricity (8 cents/kilowatt-hour)	**$35.04**	**$8.06**
Your Total Cost over 3 years	**$39.54**	**$19.06**
Total Savings over three years with the Compact Fluorescent:		**$20.50**
Source: U.S. Department of Energy, Energy Information Administration		

Incandescent *vs.* CFL

Incandescent					Compact Fluorescent				
Lamp Life =		750 hours					10,000 hours		
		Tot. Watts	Conv. To kW	Tot. kW Demand			Tot. Watts	Conv. To kW	Tot. kW Demand
kW Watts =		100	/1000	0.10	kW Watts =		23	/1000	0.02
hrs/day		Days/yr		hrs/Yr	hrs/day		Days/yr		hrs/Yr
4	X	365		1460	4	X	365		1460
Electricity Cost ($/kWh) =				$0.08	Electricity Cost ($/kWh) =				0.08
Annual Cost =				$11.68	Annual Cost =				2.6864
3-Year Energy Cost =				$35.04	3-Year Energy Cost =				8.0592
Cost of Lamps =				$4.50	Cost of Lamps =				11
				$39.54					19.0592
					3-Year Cost Savings =				20.4808

Case Study: LED Exit Signs

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Cost Comparison of Exit Signs Over 10 Years

Electricity Cost Per Exit Sign			
	Incand	*CPL*	LED
Wattage	30 – 50 watts	10 – 16 watts	1 – 3 watts
Annual Energy Use (kWh)	263 – 438	88 – 140	9 – 26
Annual Energy Cost	$21 – $35	$7 – $11	$0.70 – $2
10-Year Energy Cost	$210 – $350	$70 – $112	$7 – $21

Lamp Replacement Cost Per Exit Sign			
No. Replacement Lamps Used in 10 Years	4 – 29	6	0
Cost of Lamp Replacement	$40 – $280	$60	–
Total Maintenance and Electricity Cost Over 10 Years			
Per Exit Sign	$390 – $490	$130 – $172	$7 – $21

- 120 or 277 VAC operation.
- Injection-molded, VO flame retardant, high impact.
- LED lamp life of 25 years plus.
- Listed for damp location.
- Universal mounting for top or side installation.

Occupancy Sensors

Lighting Efficiency |

Occupancy Sensors 240 sq. ft. Bathroom

Lamp and Ballast	Watts per Fixture	Number of Fixtures	Watts per Room	**Yearly Burn Hours**	kWh per Room	Cost per kWh	Cost per Year
28 W T8 - Elec	101	2	202	**4380**	884.76	$0.10	$88.48
28 W T8 - Elec	101	2	202	**1300**	262.6	$0.10	$26.26

Without occupancy sensor:

12 hours a day 365 days a year = 4380 hours

With occupancy sensor:

5 hours a day 260 days a year = 1300 hours

Save $62.22 or 70% annually in this bathroom

Pay back will be less than 1.5 years

Summary

- *Important* - Lighting Terminology, Definitions & Formulas
- Proposed lighting retrofit systems should satisfy foot candles, color temperature, CRI, etc. requirements for the type of process at the facility we are auditing
- Proposed retrofit saves energy - *Prove it!*
- $, Savings = (Unit Cost) x (Saved Energy)
- Claimed savings are always *Estimates* : uncertainty Factor (could be reduced but not eliminated)
- Use Tools and software (Excel, GE Lamp Wizard, etc.)
- Tabulate Results w/ Payback period

Green Light Program

- **Green Lights Program is a voluntary program, first offered by the US Environmental Protection Agency (EPA) in 1991, that encourages upgrading lighting systems and controls.**
- **In 1992 Energy Star labeling was introduced, in 1996 the EPA partnered with the Department of Energy to expand the program.**
- **Green Lights is also the first step of the Energy Star Buildings program.**
- **Green Lights/Energy Star is based on adopting energy management Best Practices.**

Green Light – Cont'd

- Green Light Program Green is aimed at promoting energy efficiency and pollution prevention through investment in energy-saving lighting.

- Improvement usually provides savings for both KW and kWh.

Green Program Lighting Audit

- Under a Typical Green Lights Program, first perform a lighting survey, gathering all information on all fixture types, quantities, voltages, quality, hours of use, foot-candle levels and control calibration.
- Green Building information such as annual energy savings, cost savings, payback, and emission reduction figures are then calculated to determine which lighting equipment upgrades need to be made.
- The final report is called a Lighting Audit.

Replace Inefficient Lights

- Often inefficient lighting in a building is supplemented by less efficient portable lighting that causes increased electrical and cooling loads.
- Improving energy performance through Green Lights offers long-term, low risk returns, increases in worker productivity and improved asset value.

Upgrading Lighting

- Since lighting typically represents 20% of a buildings energy use, upgrading to a Green lights program can save as much as 35% on a typical energy bill.
- Improvements can increase worker productivity (often as much as 10 times the energy cost savings) received from performing the upgrades.

Automatic Controls

- Examine existing controls as well as recommend revisions.
- Many buildings use a variety of controls for time based, occupancy-based, and lighting level strategies.
- Adjust controls to reduce occupant complaints, maintain safety and ensure maximum energy savings.

Occupancy or Motion Sensors

- Customize the sensitivity and time- delay settings to the requirements of each individual space.
- Check each sensor for adequate coverage.
- Energy Star has a protocol available to commission sensors, call the Energy Star hotline at 1-888-STAR YES.

Occupancy or Motion Sensors& Photocells

- Check indoor or outdoor photocells to ensure the desired daylight dimming or daylight switch response.
- Adjust set-points to desired light levels.
- Photocells and dimming ballasts are used to save energy.
- Tune the set- points each time the fixtures are periodically cleaned and re-lamped.

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Q & A

THANK YOU